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1167-1345 nm Tunable Laser Operation of Chromium-Doped Forsterite

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Abstract

Room-temperature, near-infrared tunable laser operation over 1167-1345 nm range of chromium-doped forsterite for 1064-nm pumping is reported.

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Laser emission in the infrared is of technological importance for eye safe ranging, remote sensing and optical communication and medical applications. A number of chromium-based tunable solid state lasers,[1] together with $Ti^{3+}:Al_2O_3$ laser[2] span a spectral range of 660-1090 nm. Chromium-activated forsterite laser[3-7] is unique since it extends the tuning range further into the near-infrared to 1345 nm. The most important feature of the tuning range of Cr:forsterite laser is that it lies in the wavelength region of zero material dispersion. We have recently reported both the pulsed and the continuous-wave laser operation of this crystal at room temperature.[3-7] In this letter, we present the continuously tunable operation of this laser over the 1167-1345 nm spectral range.

The single crystal of Cr:forsterite used in this study was grown by the Czochralski method at the Electronic Materials Research Laboratory of the Mitsui Mining and Smelting Co., Ltd., Japan. The crystal is a 6mmx6mmx30mm rectangular parallelepiped. The chromium ion concentration in the crystal is 2.8×10^{18} cm^{-3}. The 6mmx6mm end faces of the crystal are broadband antireflection coated, such that reflectivity over the 1050-1250 nm spectral range was less than 0.5%.

The experimental arrangement used for wavelength tuning the Cr:forsterite laser consisted of the same cavity described previously[3] with an intracavity dispersive element (single birefringent crystalline quartz plate) inserted in the cavity at Brewster's angle with respect to the cavity axis.

Two sets of laser mirrors were used in the experiment. The back mirror of the first set was dielectric coated to transmit the 1064-nm pump beam and to have a high reflectivity of 99.9% in 1150-1250 nm range. With this back mirror, two different output mirrors were used: output coupler A which had a reflectivity of 98% for the 1200-1300 nm range and output coupler B with reflectivity that varied from 99% at 1150 nm to 87% at 1200 nm. The second set of mirrors consisted of the rear mirror which had high transmission for the 1064-nm pump beam and 99.9% reflectivity in the 1275-1375 nm range, and output mirror C whose reflectivity varied from 96% at 1275 nm to 94.5% at 1375 nm with maximum of 97% at 1320 nm.

The sample was longitudinally pumped by the fundamental 1064-nm, 10-ns pulses from a Q-switched Nd:YAG laser (Quanta-Ray DCR-1) operating at a 10 HZ repetition rate. The spatial profile of the pump pulse was a gaussian. The pump beam was linearly polarized along the a-axis and propagated along the c-axis of the sample. The 1064 nm beam was focused into the center of the sample by a 50-cm focal-length lens. The position of the focusing lens was adjusted to optimize the overlap between the pump-beam spot size and the cavity-mode waist. The laser output was analyzed by a 0.25-m monochromator equipped with a 1000-nm blazed grating and monitored by a fast germanium photodiode.

With the birefringent plate inserted in the cavity, smooth tuning was obtained and the result is displayed in Fig. 1.

The center curve shows the ratio of the output laser energy to the absorbed input energy as a function of wavelength, and spanning the 1205-1268 nm spectral range was taken with the output coupler A. At the peak of the tuning curve at 1220 nm, the output laser pulse energy is ~ 7 μJ/pulse for an input absorbed energy of 0.9 mJ/pulse. The tuning curve on the left covering 1167-1206 nm was obtained with the output coupler B described earlier in the text. The laser output peaks at 1200 nm with an energy per pulse of 125 μJ for an absorbed input pulse energy of 1.9 mJ. The tuning curve on the right was obtained using a pair of mirrors coated for the 1275-1375 nm range. It covers the 1236-1345 nm range. The output peaks at 1245 nm with an energy per pulse of 85 μJ for an absorbed pump energy of 2.4 mJ. It should be noted that we have obtained similar tunable operation for 532-nm pumping as well.

In summary, we have demonstrated continuously tunable operation of a Cr:forsterite laser over the 1167-1345 nm spectral range. At the peak of the tuning curve at 1200 nm an output of 125 μJ/pulse is obtained, with an output to absorbed-input energy ratio of 6.6%.

We would like to acknowledge Mr. K. Yamagishi of Mitsui Mining and Smelting Co. for growing the forsterite crystal, Mr. Ralph Page of Apollo Lasers, Inc. for providing us with the birefringent plate used as tuning element in this study, and Mr. Y. Budansky for technical help. The research is supported by Army Research Office and National Aeronautics and Space Administration.

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FIGURE CAPTION

Fig. 1 The ratio of Cr:forsterite laser output (E_L) to the absorbed pump energy (E_P) as a function of wavelength. The curve in the center was taken with output coupler A, the one to the left with output coupler B, and the curve to the right with a set of mirrors coated for the 1275-1375 nm range (with output coupler C). The transmission characteristics of the mirrors and output couplers are described in the text.

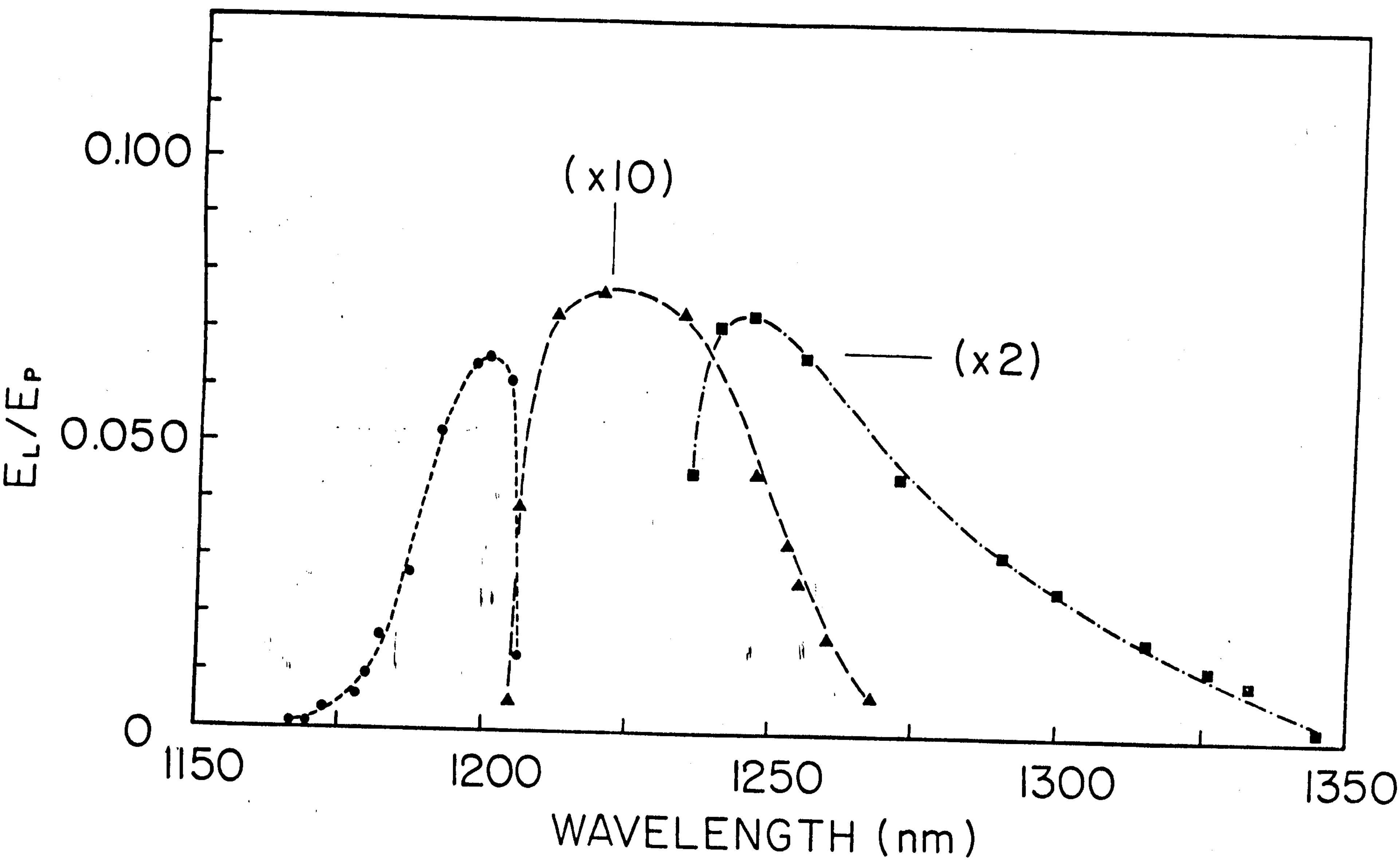
0.100
0.050
0
E_L/E_P
(x10)
(x2)
1150
1200
1250
1300
1350
WAVELENGTH (nm)

Fig. 1